

PAVONIS MONS FAN-SHAPED DEPOSITS — SMOOTH TERRAIN SURFACE ICE DEPOSITS. D. E. Shean¹ and J. W. Head¹, ¹Brown University, David_Shean@Brown.edu, James_Head@Brown.edu

Introduction and General Characteristics: The fan-shaped deposits of the Tharsis Montes generally share three major facies: 1) Ridged facies, 2) Knobby facies, and 3) Smooth facies. The ridged facies consists of narrow, parallel, concentric ridges interspersed in places with small hills [1]. The hummocky or knobby facies consists of dense concentrations of small sub-km scale circular to irregularly shaped hills [1] which are clearly highlighted by the 0.6 km wavelength in roughness maps of the area [2]. Finally, the smooth facies consists of broad convex-outward plains superposing both the ridged and knobby units.

Elsewhere, we have presented evidence supporting a cold-based glacial origin for the Pavonis deposits [3]. Here, we present evidence suggesting that the smooth facies represents residual ice deposits that have persisted until the present.

Previous Suggestions for Origin: Based on Viking orbiter data, several models have been proposed for the fan-shaped deposits, including massive landslides [4], glacial processes [1,5,6,7] and pyroclastic flows [1]. Scott et al [1] suggest that a combination of glacial and volcanic processes account for the emplacement of the fan-shaped deposits of both Arsia and Pavonis, interpreting the smooth facies as ash flow tuffs or lahars. The smooth facies has also been interpreted as a pyroclastic deposit, which emanated from large graben of the northern flank deposits [7]. We have re-examined the fan-shaped deposits utilizing new data from Mars Global Surveyor (MOLA, MOC), Mars Odyssey (Themis, GRS Suite) and previous Viking data. This analysis, together with an assessment of terrestrial analogs of cold-based glaciers [8] lead us to conclude that the Pavonis fan-shaped deposits are the depositional remains of cold-based glacier(s) that existed in recent Martian history.

Pavonis Mons Fan-shaped Deposits: The Pavonis fan-shaped deposits (Figure 1) extend approximately 250 km northwest of the shield base along a N35°W trend [7]. These deposits cover an area of about 7.5×10^4 km², approximately half of the area covered by the Arsia deposits. The Pavonis deposits consist of two large regions of knobby terrain separated by a region of the ridged facies and the overlying smooth facies.

Smooth Facies: The smooth facies of the Pavonis fan-shaped deposits covers an area of approximately 1.2×10^4 km² (Figure 2). It is mainly concentrated in one continuous deposit north of the shield extending into the central regions of the fan-shaped deposits. The smooth deposits are characterized by broad, gentle slopes with very few impact craters and vast dune fields covering the surface. These dunes are generally 5-15 m high, 30-100 m wide, with a spacing of around 50-100 m. The albedo of the smooth terrain is much lower relative to the surrounding deposits. Within the smooth terrain, thinner areas around the margins have

a lower albedo than the thicker, central regions of the deposit.

The smooth terrain superposes all other facies of the fan-shaped deposits at Pavonis. For this reason, it has been suggested that the smooth deposits may be pyroclastic flows erupted from volcanic vents after the emplacement of the ridged and knobby facies [7]. However, MOLA topography reveals that the smooth terrain does not "flow" into regions of low elevation the way such flows would be expected to behave. Instead, the smooth facies consists of convex-outward lobes with central elevations of over 800 m higher than the contact with surrounding terrain (Figure 3).

There are two smaller isolated outliers of the smooth terrain approximately 60 and 80 km west of the main deposit. The larger of the two outliers is over 60 km long and 20 km across at its widest point with a maximum elevation of around 400 m above the surrounding plains. The smaller outlier is approximately 25 km long and 10 km across with a maximum elevation of around 350 m above the surroundings. Their presence alone is evidence that the smooth facies is probably not the result of one large volcanic episode from a single source; no vents have been seen anywhere near the two outliers, which are over 150 km from the base of the shield. It is also unlikely that any pyroclastic flow would be viscous enough to achieve the observed elevations.

Instead, it appears that these outliers may be remnants of a larger, continuous smooth-terrain deposit that existed earlier in the evolution of the fan-shaped deposits. The western margin of the main smooth deposit has a large scarp approximately 60-70 km long with a relief of nearly 500 m and elevation of around 3.6-3.7 km above Mars datum, unlike the other margins of the smooth terrain, which gently slope into the surrounding terrain. The inner outlier has a length of around 60 km and an elevation of approximately 3.6 km above Mars datum. This consistency in elevation and length between the two sections of smooth terrain suggests that they may have been part of a larger smooth deposit in recent Martian history.

An additional series of ridges appear to superpose all other units of the fan-shaped deposits, including the ridged facies around the outer margins (Figure 2). These ridges are not concentric to the margins of the fan-shaped deposit and cannot be classified as members of the outer ridged facies. Instead, they appear to be concentric to the current margins of the smooth facies, and are most pronounced to the north of the smooth facies, suggesting that they are related to the smooth facies. The longest of these ridges can be traced for over 300 km and reaches heights of over 80 m above the surrounding terrain. The outermost of this set of ridges actually extends beyond the ridged facies along the northern fan-shaped deposit boundary onto the surrounding Tharsis plains. This additional set of

ridges indicates that a minimum of two phases of moraine deposition occurred.

We interpret the smooth terrain to be dust-covered residual ice from the last major Pavonis Mons ice sheet. Under current martian climatic conditions, water ice may theoretically be stable at the surface within the Tharsis rise due to the low thermal inertia of the soil and the lower mean annual temperature of the region [9]. The proposed ice sheet could have formed during periods of high obliquity [10] where equatorial regions receive less solar insulation than the poles and can become cold traps [11]. Excess water in the atmosphere would be deposited at low latitudes, resulting in significant equatorial ice accumulations. The stability of water ice at the surface is only increased with greater burial depth, and the smooth terrain is covered by dunes that appear to be tens of meters high. The smooth facies is of the order of hundreds of meters thick at present and this suggests that a significant ice component remains in the near surface today. Thus, the Pavonis Mons fan-shaped deposits could be a site where hundreds of millions of years-old glacial ice could be sampled during future exploration.

References: [1] D.H. Scott et al, USGS Geologic Map of Pavonis Mons, 1998; [2] M.A. Kreslavsky and J.W. Head, JRL, 29, 2002; [3] D.E. Shean and J.W. Head, this issue, 2002; [4] M.H. Carr et al, JGR, 82, 3985-4015, 1977; [5] R.S. Williams, GSA Abstracts, 10, 517, 1978; [6] B.K. Lucchitta, Icarus, 45, 264-303, 1981; [7] J.R. Zimbelman and K.S. Edgett, LPSC 22, 31-44, 1992; [8] J.W. Head and D.R. Marchant, Submitted to Geology, 2002; [9] M.H. Carr, Water on Mars, 1996; [10] J. Laskar and P. Robutel, Nature, 362, 608-612, 1993; [11] B.M. Jakosky and M.H. Carr, Nature, 315, 559-561, 1985.

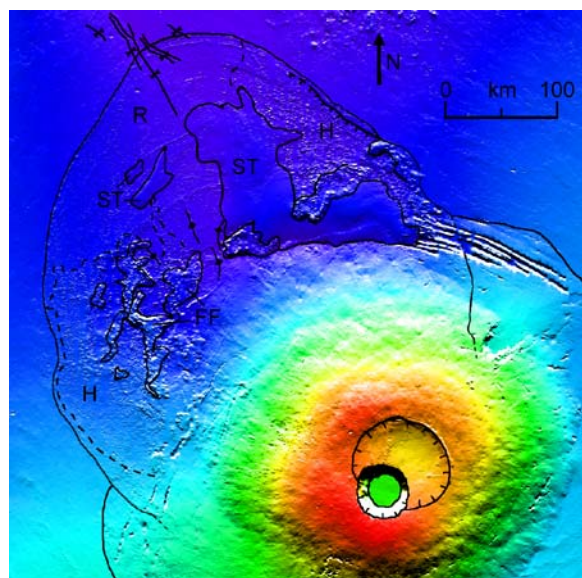


Figure 1: MOLA topography data with sketch map overlay defining units of the Pavonis fan-shaped deposits. The units are as follows: smooth facies (ST), ridged facies (R), knobby/hummocky facies (H), flow-like features (FF).

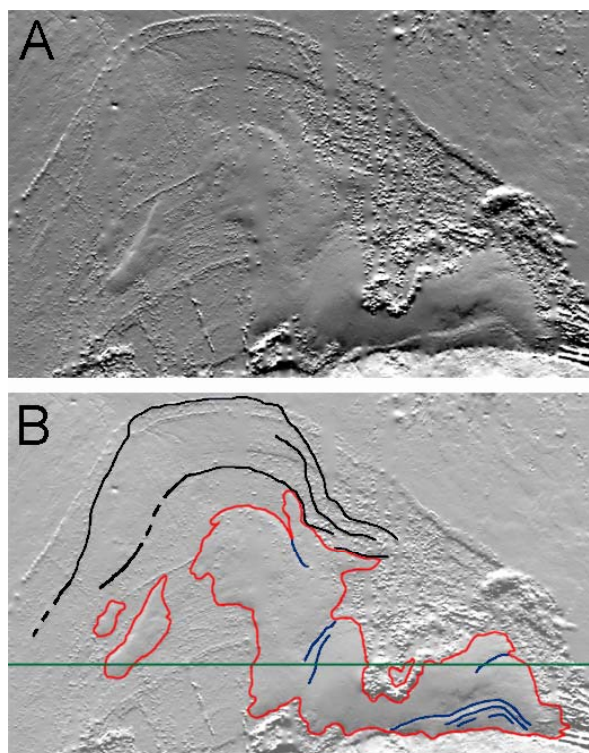


Figure 2: A) Gradient MOLA topography map of the smooth facies with false illumination from the North; B) Sketch map outlining smooth facies (red), ridges within smooth terrain (blue), and additional set of ridges (black), MOLA profile (green line - Figure 3).

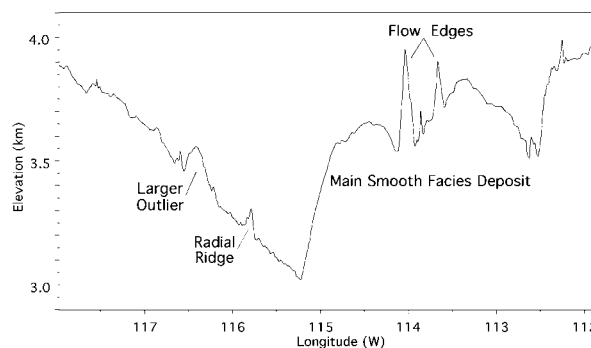


Figure 3: MOLA profile at 4.83° S (see green line in Figure 2) across the fan-shaped deposits (~188°-128° W) showing the topography of the smooth facies. Vertical exaggeration is 300x.